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Title: Mid-year Project Review on 20210586MFR "On-Machine Probe Measurement and Compensated Cutting For Improved Plutonium Shell Fabrication"

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# **Mid-year Project Review on 20210586MFR**

## **“On-machine Probe Measurement and Compensated Cutting For Improved Plutonium Shell Fabrication”**

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March 15, 2021

# Agenda

**Project  
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**Background**

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Experimental Test Bed  
At SM-39**

**Experimental  
Test Bed**

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Date



# Project Description

1. Capture part geometry 'on-the-machine' of an unclassified surrogate shell with state-of-art touch probe
2. Perform advanced data analysis to determine dimensional errors
3. Modify the tool path to compensate for error profile
4. Re-measure the surrogate shell to confirm nominal dimensions

# Background

1. Machining and Probing of Simple Geometrical Parts Has Been Practiced In Industry For Over 25 years
2. Application Of This Technology For More Complex Parts With More Complex Features Has Been Limited By Data Analysis Software Development
3. Preliminary Development At LANL Was Initiated Through A CRADA With Aerotech Inc In 1997
4. Proof-on-Principle Has Been Demonstrated With Simple Solid Parts



# Background (Cont)

5. Precision plutonium shell machining is a key process for pit manufacturing
6. Fabrication of low-rigidity (“flexible”) shells is a difficult process
  - setup is dependent on the skill of the machinist
  - use of a touch probe for geometry measurement has not been implemented
  - “closed-loop” machining is the ultimate objective
7. Proposal: Form error due to part deflection can be measured and corrected on the lathe



# Research Approach

1. Using an under-utilized lathe at SM-39, an unclassified surrogate shells will be machined to a set of predetermined wall thicknesses
2. For each wall thickness, the profile error will be measured with a 0.25 micron resolution touch probe
3. Using data analysis software, corrections to the previous tool path will be calculated and uploaded to the lathe controller
4. Re-measurement the surrogate shell will performed to confirm dimensions after the corrected machining pass has been completed



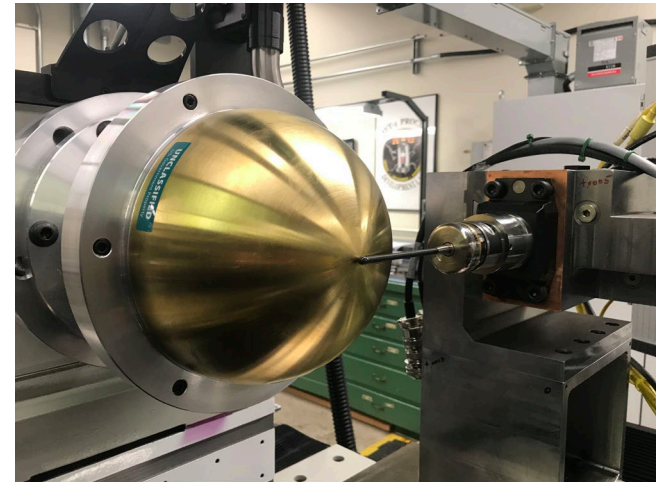
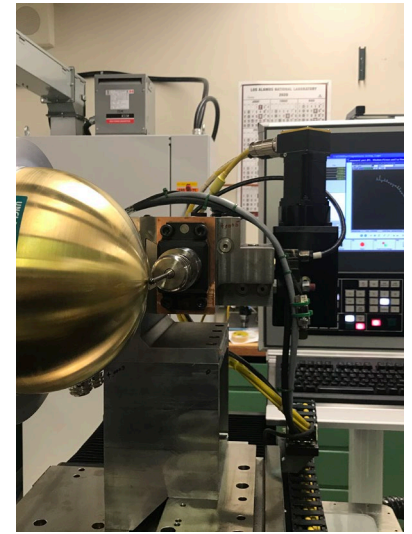
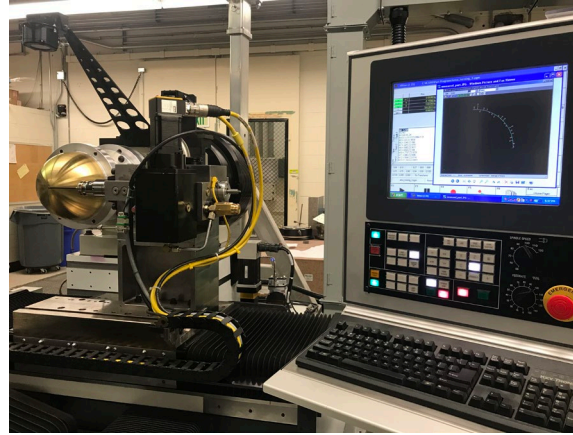
# Goals Of Experimental Test Bed At SM-39

1. Capture part geometry 'on-the-machine' of an unclassified surrogate shell with state-of-art touch probe
2. Perform advanced data analysis to determine dimensional errors
3. Modify the tool path to compensate for error profile
4. Re-measure the surrogate shell to confirm nominal dimensions



# Experimental Test Bed

- Adapted ARIES Backup Pit Disassembly Lathe To Machine And Measure Surrogate Shells.
- Equipment Uses Same Controller As Precision L-Base Lathe In PF-4.
- Test Shells Are Legacy Artifacts Used For Cold Testing Of Operational Lathes Within ADLWP.



# On-Machine Data Analysis Methodology

1. Probe-acquired positional data will be dynamically captured as text (complete)
2. A C#-python application resident on the controller will perform cubic spline interpolation and display contour errors (50% complete)
3. The same application will compensate for these errors and generate a revised tool path in G code (10% complete)
4. After re-machining, the part will be probed for confirmation of corrected geometrical errors (0% complete)



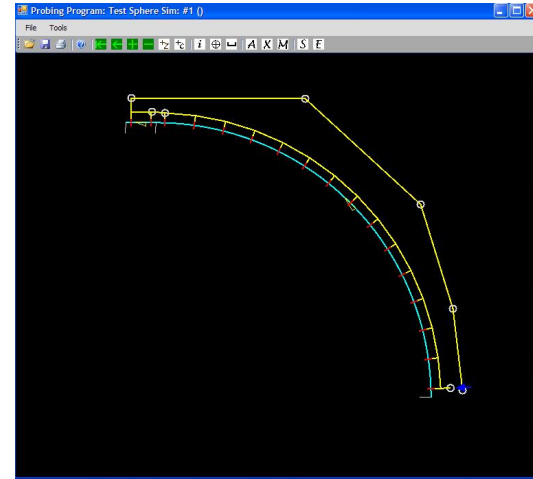
# Proposed Experimental Matrix

1. Unclassified shells made of 6061 Aluminum, Brass, and Copper
2. Target wall thicknesses: 3mm, 2mm, 1mm, 0.5mm
3. Research least two curve fitting algorithms to optimize poly lines
4. Independently inspect contours on high accuracy CMM at SM-39



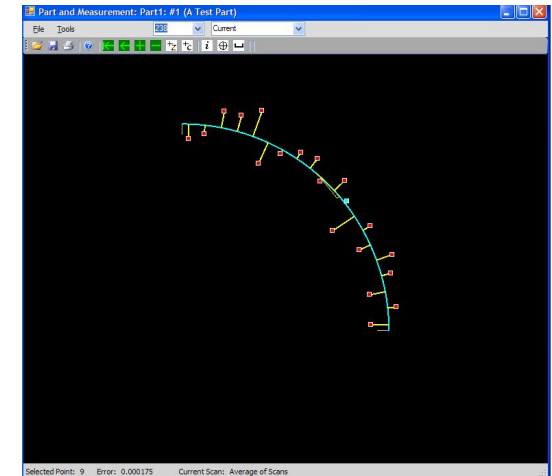
# Results To date

- Output Graphics In Standard WinForm Objects Have Been Developed To Aid Visualization Of Planned Probing Paths And Results
- Tool For Creating And Manipulating The Data Is Microsoft Visual Studio



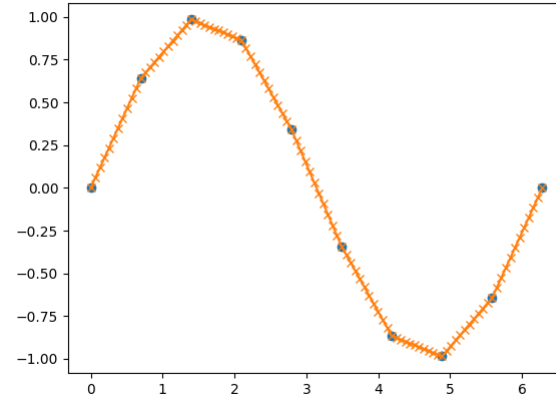
Graphical User Interface For Probing Path Simulation

Example Of Geometrical Error Plot Using Probe Points



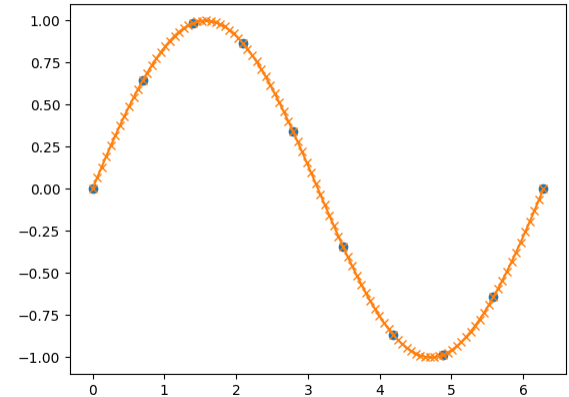
# Results To date

- Standard Python Data Analysis Modules Look Promising for Quickly Evaluating and Plotting Probing Values
- Test Shells Have Been Fabricated
- All Equipment Is Operational To Begin Feasibility Study



Poly Line Fit of  
Linear  
Interpolation  
Algorithm

Poly Line Fit of  
Cubic Spline  
Interpolation  
Algorithm



# Summary

1. Significant Progress Has Been Made To Advance The Development Of On-Machine Probing And Error Compensation Of Form Errors On Surrogate Shells
2. Experimental Test Bed is Operational For Machining and Probing Surrogate Shells

